Mid-Atlantic Technology, Research & Innovation Center
MATRIC

Development of New Chemical Products and Processes
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Agenda

- MATRIC Description
- Development Process
- Examples
  - Chemical Technologies
  - Energy Technologies
  - Environmental Technologies
- Summary
About MATRIC

- MATRIC is a non-profit research and development corporation formed in 2004
  - Reinvest earnings in new research
  - Offices in Charleston (WV), Morgantown (WV) and Oak Ridge (TN) and Milan, Italy
- Research and engineering staff of nearly 150
  - 33 PhD-level researchers
  - 9 professional engineers + access to Dow downsized staff
  - 25+ average years of experience
  - 2 members of US National Academy of Engineering
- MATRIC has a focus on developing intellectual properties and adding value throughout the R&D, engineering and commercialization processes

MATRIC was formed from the downsizing of over 2000 research scientists and engineers located at the Union Carbide Tech Center, South Charleston, WV from 2001-2008
South Charleston Technology Park Facilities

- World-Renowned Research and Development Campus
  - 651 acres
  - Two major chemistry laboratory buildings
  - Three major pilot plant complexes
  - Major engineering building
  - Major computer data warehouse

- MATRIC currently occupies Building 740
  - Over 35 wet chemistry labs
  - Engineering space
  - Access to over 32 multi-story high pressure pilot plant cells

- West Virginia university system in investing over $40M in new training facilities at the Tech Park

Significant history of R&D at this site
- Over 30,000 international patents
- 286 of the largest 500 chemicals in the world first produced here
Full Innovation Life-Cycle Service

Laboratory and Pilot-Scale Research and Development to Create New Innovation
(intellectual property development)

Professional Engineering to Implement Innovation
(detailed design, construction management, operations training)

Commercialization to Access Markets (license or start-up companies)
MATRIC Business Areas

Chemical, Energy and Environmental Technologies Business Area
Health and Life Sciences Business Area
Advanced Engineering Systems Business Area

Non-Profit Focus on Government and Scientific R&D
Commercial and Industrial R&D within Scope of Charter
Chemical, Energy and Environmental Technologies: Product Areas

- **Member of NETL Contractor team for Energy R&D**
- **Fossil Fuels and Products**
  - Ethane derivatives from Natural Gas
  - Coal to Liquids/Chemicals
  - Coal Gasification
  - Integrated Gasification Combined Cycle
  - Mine safety equipment
- **Biomass Fuels and Products**
  - Biodiesel development
  - Corn ethanol development
  - Cellulosic ethanol development
  - Biomass gasification
  - Anaerobic digestion
  - Bio-polymers and chemicals
- **Environmental Technologies**
  - Carbon dioxide capture
  - Water purification
  - Natural gas purification
  - Selenium and metals removal
  - Nuclear remediation
  - Soil restoration
- **Pharma and Fine Chemicals**
  - API process development
  - Microreactor systems
Chemical, Energy and Environmental Technologies: Capabilities

- **Process and Product Development**
  - Economic-directed research
  - Radical process innovation & synthesis
  - Process and plant improvement
  - Product and prototype development
  - Materials development & testing
  - Modeling using Aspen and Chemcad
  - Scale-up, pilot plant development & demonstration
  - Product manufacture for market development & testing

- **Separations Technologies**
  - Membranes
  - Distillation
  - Crystallization
  - Reactive media,
  - Simulated moving bed
  - Other advanced techniques

- **Catalysis**
  - Catalyst design & scale-up
  - Testing & modeling
  - Substrate design
  - Reaction engineering
MATE Capabilities and Skills

- **Detailed Engineering**
  - Chemical process engineering
  - Control system engineering
  - Electrical system engineering
  - Mechanical engineering
  - Civil engineering, Drafting

- **Procurement**
  - Major and Minor equipment
  - Bulk material

- **Construction Management**
  - Construction oversight
  - Process Representation

- **Operations Training and Start-up**
  - OSHA training
  - Process operations training
  - Plant process start-up support

- **Project Management**
DEVELOPMENT PROCESS
Iterative Development Process

- Identify highest risks
- Create technical model
- Create early designs for products or processes
- Create economic models
- Economics
- Conceptual design
- Laboratory research

Integrated Technical Team includes representatives from all phases of development, through manufacture

Tackle the hardest problems first

Develop framework for scientific investigation

Utilize disciplined work processes to maximize lab activity

www.matricresearch.com
Examples

CHEMICAL TECHNOLOGIES
MATRIC has developed a process to produce ethylene and downstream integrated chemicals using a catalytic cracking technology

- Lower capital costs (<40%)
- Lower operating costs (exothermic)
- Fewer down-stream products
Coal to Chemicals

- Syngas-derive chemicals portfolio
  - Ammonia
  - Methanol
  - Olefins
  - Glycols

- Advanced catalysts
- Market development and pilot demonstration
- World-scale plant engineering and design
Coal Freeze Conditioning

- AKJ Industries supplies the coal industry with solutions that prevent coal from freezing to the sides of rail cars.
- MATRIC developed a new formulation for AKJ having 10X better performance.
- The new formulation has been successfully commercialized.
- MATRIC is continuing to support AKJ in expanding the market for this product.
Integrated Biorefinery

Technology development, design and engineering of an integrated biorefinery for a major Mid-West USA military facility

Plant includes:
- Flexible feed ethanol production
- Flexible feed biodiesel production
- Flexible feed anaerobic digestion for methane production
- Gas turbine electricity production
Algae Development

- MATRIC is working with a number of academic and industrial partners to utilize microbial algae to:
  - Capture and sequester carbon dioxide
  - Develop algal oil-based biofuels
  - Create new food additives
  - Produce bio-derived polymers
- MATRIC is working in the areas of extraction and overall reaction system design

Courtesy: Greenfuelworks.com
MATRIC has developed and scaled a process for converting corn sugar to isosorbide, a valuable polymer intermediate.

Pilot plant production of several 100s of pounds per month have allowed for testing in larger scale manufacturing systems.
Fermentation Derivatives

- MATRIC has created processes to produce airport de-icer products from biological fermentation
- MATE has engineered the full-scale fermentation process design
- A large-scale pilot plant has been developed and operated for market introduction
Large international bio-polymers company worked with MATRIC to dramatically increase their production throughput
- Approaching 2x improvement
- Implemented process design improvements to all “bottle-necked” process steps
Cellulosic Ethanol Development

- MATRIC is currently researching advanced cellulosic pre-treatment technologies which will economically liberate the C5 and C6 sugars.
- MATRIC and MATE participated in the design and engineering of several cellulosic demonstration facilities for a variety of government and private-sector funded projects.
Examples

ENERGY TECHNOLOGY
Oxy-Fuel Combustion

- MATRIC is developing oxygen membranes for use in traditional combustion processes
  - Allows for more efficient combustion and overall cycle efficiency
  - Creates a nearly pure stream of CO2, which aids in GHG capture and sequestration
Pyrolysis Systems

Pyrolysis heats biomass in the absence of oxygen

Products: Methane, Bio-oil, Water and Char

- Feed: Various biomass (ag waste, wood, switchgrass, landfill waste, etc.)

Projects conducted include:

- Pyrolysis demonstration with various biomass material with Cornell University
- Design of 40-ton per day pyrolysis units in Australia
- Development of novel variable reaction pyrolysis reactor system
- Major 1000+ acre bio-char demonstration in Illinois
- Design of 20-ton per day pyrolysis unit in Wisconsin
- Design of 100,000 ton per year pyrolysis system in West Virginia
Biodiesel System Development and Plant Construction

- The new biodiesel process developed for BEST Energies has been designed for a facility in Cashton, Wisconsin.
- MATRIC completed laboratory development, detailed engineering and design for the plant and provided engineering construction support and operator training for the plant.
- Plant start-up was successfully completed in December 2007.
- Both esterification and transesterification of high FFA oils.
MATRIC has developed a novel process that can flexibly utilize corn, sorghum, wheat, cane and other feedstocks to produce traditional ethanol. MATRIC’s small scale design reduces both the water and energy consumption through the use of advanced proprietary water separations technology, which will reduce plant operations costs by up to 50%.
Anaerobic Digestor

- MATRIC has worked with West Virginia State University to develop economical systems to create methane and other biofuels from animal wastes
  - Research is focused on chicken wastes
- The process uses enzymes in a depleted oxygen environment to metabolize the biomass materials
- Design and construction of several digestors in Florida, Missouri, Virginia and Europe
Examples
ENVIRONMENTAL TECHNOLOGY
Carbon Capture

- MATRIC has worked with the Department of Energy to develop novel technology to capture carbon dioxide in fossil fuel plants.
- MATRIC’s adsorption technology can reduce the parasitic electrical load from 30% to 3%.

Up to 70% of the cost for carbon sequestration is in the capture process at the power plant.
MATRIC started a company, NG-Innovations, LLC that provides natural gas treatment technology for oil and natural gas drilling operations.

Technology developed to allow natural gas producers to clean up their gas at the wellhead.

Goal is to generate a higher-quality, less corrosive gas that will provide greater value.
Natural Gas Well Desalination Unit
Surface Mine Water Selenium Removal System
Reverse Osmosis Technology
Surface Mine Water Selenium Removal System
Reverse Osmosis Technology
Surface Mine Water Selenium Removal System
Reactive Filtration Technology
Surface Mine Water Selenium Removal System
Reactive Filtration Technology
Summary

- MATRIC uses a disciplined work process to create innovative products and processes for the commercial marketplace.
- The breadth of our innovations has allowed for rapid international growth.
- Our business focuses on long-term relationships with our customers and collaborators.